chambers and diagnostics components. Figure 1 shows shielding of the downstream flanges and bellows by the crotch and wedge absorbers.

In this paper we discuss guidelines that were adopted for designing the APS storage ring absorbers. Several unique absorber designs used in the ring are presented.

2. Design Guidelines

A number of design concepts were studied during the initial development phase. A beryllium ring was used as an energy diffuser [1,2] in one of the early designs. However, during the brazing tests, unacceptable voids were found in the braze joints between beryllium and oxygen-free high-conductivity (OFHC) copper [3]. A prototype was then made from beryllium copper as a casting, but this fabrication approach was also abandoned because of the possibility of voids and outgassing. Enhanced heat transfer using microchannels and porous media were evaluated by finite element (FE) models. These approaches were not pursued, however, because of the risk of clogging water passages with contaminants during the start-up phase. Clogging can also occur from deposits of cuprous oxide resulting from dissolved oxygen in deionized water.

The following guidelines were subsequently followed to develop absorber designs that were cost-effective and satisfied the requirements of high reliability and low maintenance.

- **Water-to-Vacuum Joints**: Water-to-vacuum braze or weld joints are not used. This is a general APS design requirement that was instituted to prevent water leaks from entering into the vacuum system.
- **Materials**: All high heat-load absorbers are made from Glidcop [4] because of its high thermal conductivity, high strengths at elevated temperatures, and UHV compatibility (low outgassing). OFHC copper is used for absorbers at lower power densities (i.e., farther away from the source point) when maximum temperature rise, as calculated from FE models, does not exceed 150 °C.
- **Braze Joint**: Brazing over large surface areas is avoided to eliminate the possibility of voids. To further minimize the effect of voids, braze joints are designed to be away from the region between the beam footprint and water channels. Only gold brazing (with 3565 AuCu) is used to braze Glidcop to OFHC copper or stainless steel.
- **Cooling**: Deionized water cooling (without boiling at the interface) is used for cost-effective and conservative designs. Cooling channels are designed to be within 3 to 5 mm away from the beam footprint to optimize heat transfer [5]. Water velocity in the cooling channels is kept in the 3-5 m/s range in order to keep flow-induced vibrations within acceptable levels.
- **Fatigue Life**: The absorbers are designed for a minimum fatigue life of 20,000 cycles. As a rule of thumb, this can be achieved (with a safety factor of 1.5 – 2) by limiting temperature rise to within 150 °C for OFHC annealed copper and 300 °C for Glidcop.